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TECHNICAL REPORT

THE ICE BUDGET OF THE ARCTIC PACK AND ITS APPLICATION TO ICE FORECASTING

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ABSTRACT

The annual cycle of the Arctic pack is considered from the viewpoint of aerial ice reconnaissance. From statistical considerations, figures are presented showing the amount of melting, amount of new ice formation, and the average age of the remaining polar ice under various assumptions. It is demonstrated that, in the polar seas, the ice forecaster must consider the composition of the pack as well as other factors because of the different physical characteristics of winter and polar ice. Future variations in pack composition may result from the present trend toward the warming of the Arctic, with resulting operational effects.

FOREWORD

In recent years the growth of Arctic operations has brought an increased concentration of effort directed at facilitating ship movements in the Arctic basin. This report summarizes the latest information about the nature of the Polar Pack, its age and volume, and provides aids in forecasting changes in the ice from the operational point of view.

The Hydrographic Office is engaged in developing techniques of forecasting ice conditions in all the waters where ice is present. Since this report is tentative and much of the information is based on little data, it is requested that activities receiving this publication forward their comments to the Hydrographic Office.

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CONTENTS

TABLES

A. INTRODUCTION

The Arctic pack is a floating aggregation of pieces of sea ice of all sizes, from huge masses many miles in diameter to broken pieces not much larger than snowflakes or sleet particles. Principal types of ice which are now recognized are young ice, winter ice, and polar ice. Young ice is newly-formed thin ice which from the air appears grey or black in color and has an age measured in days or weeks. Winter ice develops during the winter season and may be several feet thick; much of it melts during the succeeding summer. Paleocrystic or polar ice is ice that has remained unmelted through one or more summers and is much harder and thicker than winter ice. It has a pale blue color, and because it partially melts during the summer, it has subdued relief features, the surface being composed of small ridges and valleys in which a system of fresh-water rivulets flows during the summer.*

With the establishment of regular weather reconnaissance flights over the ice pack, observations of the pack in all stages of freezing and melting have been made. It is now possible to formulate theories to attack some of the unsolved problems concerning the nature of the pack. This paper outlines a theory covering the annual cycle of the pack and the age of the polar ice, together with some characteristics of the pack and a consideration of some of the problems of forecasting the movements of the pack.

B. A THEORY OF POLAR PACK HISTORY AS APPLIED TO THE ALASKAN AREA

The annual cycle of the Polar Pack is probably as follows. In the winter the whole Arctic basin is covered by an elastic ice sheet in which many short, narrow leads and cracks are opened and closed by the stress of wind and currents and by expansion and contraction of the ice. At the edge of the ice sheet there is continual breaking away of floes, but in the inner portions the wind force is mainly exerted in the formation of pressure ridges. Sea ice is elastic because of its salt content and thus is readily forced into ridges by pressure, the ice bending instead of breaking. Because of the salt content the final breakup in summer is caused not primarily by the external wind and current stresses but by melting of the salt water and salt crystals imbedded in the ice, which have a melting point lower than that of the less salty clear ice. Since prevailing winds during winter are northeasterly, a northerly stress is applied to the ice sheet, forming large pressure ridges on the shores of northern Alaska, western Banks Island, and other exposed areas.

The summer breakup of the ice is as follows. West of Point Barrow the northerly transport of warm water begins in spring, the current opening a lead from Bering Strait northward. At the same time the land warms up, rivers begin to flow after their winter freezeup is ended, and the warm river water is carried to the ice to act as a melting agent. When

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*For a complete description of ice and for an explanation of the technical terms in this paper, reference should be made to H.C. Pub. No. 609, A Functional Glossary of Ice Terminology.

the land warms still more in the continuous daylight, a shore lead develops between the outer sand spits and the main ice pack. Further warming of the ice by the continuing transport of warm water from the Bering Sea and the rise of air temperatures to about 30-35 degrees F. causes much melting of the inner pack, with floes becoming detached at weak points and the water surface being covered with from 8 to 10 tenths floes and blocks. At this stage in the melting, wind stresses can cause rapid changes in the concentration, packing the ice from a loose coverage of 6 tenths to a coverage of 10 tenths in a matter of hours. The wind can thus close or open the shore lead temporarily. In midsummer there is always open water toward the middle of the basin, with about one tenth open water observed at 84°N 144°W and about 5% open water near the North Pole. The heaviest concentrations occur because of wind- and current-driven packing on windward shores.

Midsummer conditions in the Arctic basin show the pack at the stage of maximum deterioration. North of Alaska there is open water everywhere between the ice floes. The size of the remaining floes ranges from blocks to giant floes, with few fields present. Floes have been measured at from 1½ to 2½ miles in length, but complete listing of sizes is not possible at the present time. Floes which are made up of old ice remain longer than those composed of winter ice. Ice islands, or land shelf ice, float through the pack as isolated, strong, thick, single floes; they are very rare, with probably not more than a score or so existing in the Arctic basin at the present time. (Hundreds of small ice islands are located within the Canadian Archipelago.) The hard, blue polar ice remains throughout the summer, although it becomes heavily puddled. In the summer months the southern edge of the main pack lies approximately 25 to 50 miles offshore from northern Alaska, thence westward at 71°N to Wrangell Island. North of Canada the pack boundary runs northeastward toward the northwest tip of Banks Island. The edge of the pack is ordinarily well defined, with few areas of ice separated from the main body. Occasionally a belt of blocks and small floes is detached by winds in the Chukchi Sea and floats northward on the current toward Point Barrow, causing interference with shipping during its passage. In the area east of Point Barrow the pack moves almost as a unit, wind forcing the edge inshore or offshore, the concentration at the edge changing with wind direction.

At the end of the short polar summer, freezeup occurs, and the surface of the Arctic Ocean is transformed from floes separated by open water to the typical winter condition of solid coverage with ice under heavy pressure. The freezeup is the reverse of the summer breakup in many respects. The freezing begins in the inner areas of the pack when falling air temperatures, due to radiation, cause the formation of young ice in the open leads and cracks. The relative freshness and low salinity of the open water facilitate this freezing, since the freezing point is near 32°F. The first formation of young ice occurs in mid-August, and is followed by alternate thaws and freezes until late September or early October, when the coverage becomes and remains essentially ten tenths until late April or May. Wind stress forms pressure ridges between the strong hard floes of polar ice, and the young ice, which is very elastic,

is separated or forced together by the wind flow. Thus the newly-formed pressure ridges are proportionately weaker than the old floes although much thicker. In early September the warm current from the Bering Sea loses some of its velocity and heat, and water temperatures fall. Next the land mass, which in spring warmed faster than the water, cools faster than the water, so that near shore the blocks and small floes freeze together into giant floes, which then may become detached by winds and currents, and drift until finally frozen into place. The last portion of the water to freeze is the shore lead, where the relatively warmer and more saline water cools off very slowly. The pack proper, therefore, extends southward finally joining the shorefast ice spreading northward from the land. The process of growth of the pack is facilitated by the fact that the shore lead is never completely free of ice, and the few remaining floes act as nuclei for the growth of winter ice. Continued low air temperatures cause thick ice to form quickly over the open leads in the pack, so that frozen leads form the smoothest portion of the ice sheet. In the interval between summer and winter conditions many pressure ridges are formed, while cracks and leads form and freeze over, reform and refreeze, and so on. At the edges of the ice mass there is never complete freezing, since the alternate motion back and forth of the wind-driven pack prevents the forming of thick ice. The elasticity of the ice depends on the rate of freezing. Ice in the newly frozen leads freezes quickly and retains many salt crystals in its contitution, so that it is weaker and more elastic than the older ice. During the winter the older polar floes add some ice from the bottom and are also covered with snow, but the accretion of ice is slow and does not contain much salt. Therefore, the old floes are hard and brittle.

Currents play an important role in the life cycle of the Arctic ice. The transport of warm water to the north causes semipermanent zones of weakness where the ice is thinner than in other areas. One such area exists along the coast of Alaska from Bering Strait toward Point Barrow. Other areas of warm-water currents have not yet been delineated because of difficulties of winter reconnaissance. Currents carrying cold water also influence the ice. In the Arctic the cold currents are much weaker than the warm currents, so that the ice is carried slowly in an anticyclonic (clockwise) whirl around the basin. By being carried within the basin, the ice has a chance to remain unmelted for some time, and the ice islands in particular must have been floating for many years in the basin. The hard polar ice is thus partly due to the existence of the anticyclonic current whirl.

The validity of this theory of ice pack development and history cannot be determined without further data. Two postulates may be listed: (1) that the gross total amount of ice in the Arctic basin remains constant, and (2) that the total volume of ice varies from year to year. It is possible that the volume of ice remains essentially unchanged from one year to the next, due to similar wind and current conditions. If this is true, the causes of heavy or light ice years are the wind and current stresses on the ice pack. Wind forces will cause a packing of ice in one area one year and in a different area the next, so that if an

area is closed in with ice under pressure, it is likely that other areas oppositely situated in the basin will experience light ice years with little pressure. On the other hand, if the total amount of unmelted ice varies greatly from year to year (more than 5% or so), it may be possible that all areas will have light or heavy ice years simultaneously. On the basis of present observations, especially during the summer of 1953, the former statement seems more likely: that there is essentially the same amount of ice in the Arctic each year.

C. ECONOMY OF POLAR ICE

If the polar ice is generally several years old and is moving around the basin in an anticyclonic whirl, the only chance of its disappearance is through melting or by being carried out of the polar basin into lower latitudes. The polar ice that is carried away from the basin consists almost entirely of the outflow of the East Greenland current through the Denmark Strait. Sverdrup, Johnson, and Fleming, in The Oceans (p. 655, 1942) estimate the volume of the current at 3.55 million cubic meters per second, or about 112,000 cubic km. per year. The estimate given by Zubov (1948) is 80,000 cubic km. per year. The former estimate of 112,000 cubic km. per year corresponds to a current 200 km. wide and 200 meters deep moving at an average speed of 7.65 km. per day. The ice floats on the surface of this current which moves at about 20 to 25 km. per day, so that it is possible to estimate the outflow of ice from the volume of the current. The oldest estimate, probably that of Nansen, is usually quoted as 26 billion cubic yards annually (e.g., Brown, 1927 and Rodahl, 1953). If this figure is British and means 26 million cubic yards, it amounts to about 25,000 cubic km. annually and is far too large; while if it means 26 thousand million cubic yards it is roughly 25 cubic km. and far too small. Zubov refers to Vize's estimate of 8,000 cubic km. of ice annually and gives his own more conservative estimate of 3,000 cubic km. based on his calculation of a current 200 km. wide moving at from 8 to 12 km. per day and covered with ice averaging 3 m. thick. Recently Weaver (n.d.) has estimated the total ice outflow at 3,000 to 4,300 cubic miles per year; this is from 12,500 to 18,000 cubic km. annually and is thus several times as large as Zubov's figures. Using Zubov's reasonable figure of a current 200 km. wide with a speed of 20 km. per day, and assuming an average thickness of the ice of 3 m., ice completely covering the current would total 4,380 cubic km. per year. However, there are two reasons why the total amount of ice is less than this figure. One is that the area of the East Greenland Current is not always covered with ice. During the months of August and September, the current often contains only scattered drift ice, and ships sometimes can go from Iceland to Greenland with little interference from ice. It may be assumed that over the year the average coverage is no greater than 80 percent. Secondly, not all of the ice carried by this current is polar ice. Present observations of the ice indicate that about 70 percent of the ice in the East Greenland Current is polar ice, the other 30 percent comprising winter ice from the Greenland coast, Barents Sea, and other localities. Thus, the total amount of ice of polar origin carried southward through the

Denmark Strait is 56 percent of 4,380 cubic km. annually, or 2,350 cubic km. per year. This figure is 20 percent less than Zubov's, 70 percent less than Vize's and 80 to 85 percent less than Weaver's estimate.

The total mass of ice in the Polar Basin is estimated at 28,000 cubic km., assuming an area of 8 million square km. and an average thickness of ice of 3.5 meters. The Oceans, estimates the average thickness of the ice at 3 to 4 meters in winter and 2 to 3 meters in summer. Thus, 9.2 percent of the polar ice drifts away each year.

In order to calculate the average age of the polar ice, it is necessary to consider the different melting properties of the polar and winter ice. Due to the hardness of the polar ice and its lack of salt, it melts more slowly than winter ice. Therefore, the percentage of winter ice which melts in the ensuing summer should be much greater than that for polar ice. It is known that about 3 feet of ice are melted annually from the surface of the ice pack (Malmgren, 1927). It is necessary to redefine the melting as referring to the percentage of the area covered which is decreased through melting, rather than the volumetric change of ice. Considering the areal coverage, winter ice should "melt" faster than polar ice, because it is thinner and saltier. If, for example, 10 percent of the polar ice drifts out of the basin annually, and melting of the polar ice amounts to 1 percent in area, and if the total extent of ice is 95 percent in summertime, composed of 85 percent polar ice and 10 percent winter ice, statistically then 28.6 percent of the winter ice area is melted and the average age of the polar ice is 8.7 years. Tables 1 and 2 give the melting percentages of winter and polar and the average age of the polar ice for area coverages of 95 and 90 percent in summer, thus including the probable range of area coverage and percentage composition of polar and winter ice. Further aerial reconnaissance is necessary to secure better estimates of the surface ice coverage and the relative proportions of winter and polar ice during the summer season. Note from the tables that if 10 percent of the ice drifts away each year and if the melting of polar ice amounts to as little as 1 percent of the basin area, no more than 89 percent of the surface of the basin can be covered with polar ice during the summer months, regardless of the formation or melting of winter ice.

The percentage of winter ice is fairly high, even in the middle of the Polar Basin. On the basis of available surface and aerial reconnaissance, the areal coverage of the basin is greatest between the North Pole, Spitzbergen, and Greenland, where the constriction due to incoming and outflowing currents give summer coverages of 98 or 99 percent, whereas the section of the basin between the Laptev and Beaufort Seas may have a summer coverage as low as 70 percent in places, and an average of perhaps 90 percent. The proportion of winter ice must therefore be greater in the latter area, but as the ice moves in the slow drift over the Pole and into the East Greenland current, the percentage of winter ice decreases until practically all of the outflow is polar ice.

D. SOME CHARACTERISTICS OF THE POLAR PACK

The geographical center of the Arctic polar pack is approximately 85°N 180°W. The pack covers an area roughly rectangular in shape, between Novaya Zemlya, Svalbard, Banks Island, and Ostrov Vrangelya, plus some projections out from the rectangular shape, especially on the Siberian side. The Canadian Archipelago acts as a shield preventing the pack from extending further into the Western Hemisphere. Each day the Ptarmigan weather reconnaissance flights reach close to the center of the pack.

Ice at the geographical center of the pack does not move much. Thus the concentrations in that area are observed to remain more or less constant from day to day, making allowance for the varying areas of the surface that are visible from the planes' altitude. The center of gravity of the pack moves back and forth due to temporary packing and thinning near the edges caused by wind movement and other factors. If the edge moves, for example, 50 miles, the center of gravity is changed, even though the ice at the geographical center may be stationary. However, in order to move the edge a distance of 50 miles, a wind movement of 2500 to 3000 miles is necessary, or the equivalent of a 25-knot wind blowing for 100 to 120 hours. Such wind movement in the Arctic is known, but it is rare in the summer months at which time pressure gradients are usually weak except near the center of the occasional LOWS which move through the basin.

There are large-scale differences from one year to the next in the ice boundary locations along Alaska's north coast, the boundary varying from a few miles offshore to 100 or 150 miles offshore. From the wind movement specified above, which would necessarily have to be southerly or southeasterly in opposition to the prevailing northeasterly wind, it seems unlikely that wind stress is the primary factor causing this year-to-year change. Other possible factors are water temperature changes, variations in the continental warming, and changes in currents.

Variations in the temperature and strength of the current coming through the Bering Strait may be responsible for the differences in pack boundary locations. If the amount of warm water entering the Bering Sea is subject to variations from year to year, the heat energy available for melting the pack would vary correspondingly. Thus, variations in the Kuroshio may account for the year-to-year changes in the pack boundary in the Alaskan area. No data to test this theory in the Alaskan sector have been collected.

Another differential factor may be variations in the warming effect of the continent. This is not likely, since the over-all cloud coverage and hence potential insolation and outgoing radiation are quite constant from year to year, when averaged over a period of months. Solar radiation data from Barrow and Aklavik tend to support this last statement.

Still another factor may be a breakup at the edge of the pack due to temporary strong winds, with subsequent rapid melting of the ice and

recession of the pack boundary northward. The rapid melting of the ice is attested by several observers in past years and represents a probable change in currents according to the following reasoning. The rapid melting can only occur if the ice in question is winter ice, since polar ice melts slowly due to its physical characteristics. If the quickly-melted ice is winter ice, the edge of the polar pack must be far north of the Alaskan coast. But by hypothesis, during the previous summer the pack boundary was close to shore. Therefore, the movement of the polar ice away from the coast occurred during the previous winter and must have been the result of a steady slow movement of the ice. A current is suggested, and it is possible that during the winter the current from Bering Sea and the anticyclonic Beaufort Sea whirl may have been stronger than usual, so that all the polar ice was removed from the Alaskan coastal area, leaving only winter ice to be melted after the wind breakup. Very little is known of winter changes in currents around Alaska.

The packing of the ice due to the wind is greatest at the edges, since the differential frictional coefficient between water and ice is greatest at the edge. The wind forms windrows near the boundary but not deep within the pack. Homogeneity of the surface and the resulting decreased differential frictional coefficient are responsible for the slow changes in concentration at the center of the pack.

Much of the pressure on the coasts of the North American side of the pack, from Greenland to Banks Island, probably is caused by currents which drive the ice against the land, rather than by wind stresses. The most impenetrable ice is found along these coasts and in the outer portions of the Canadian Archipelago. Within the archipelago, the warming effect of the land induces melting during the summer, so that most of the ice is winter ice. The shore lead which is so prominent along the Alaskan coast and Banks Island usually is absent between Prince Patrick Island and Greenland; of late years no observations from the Lincoln Sea have ever shown any wide lead comparable to Peary's "Big Lead", and it is doubtful if there ever are large leads along this coast, due to the pressure of the ice.

A trend in warming of the Arctic has been discussed at length in the literature (e.g., Zubov, 1948). As regards the polar pack, the average thickness of the ice has been estimated to have decreased about one meter in the past fifty years (Zubov, 1948). The implication of this statement for ice forecasting is that the summer coverage of the Polar Basin must be decreasing slowly, as the thinner ice is more easily reduced in area ("melted") than thicker ice. The thermal structure of the surface layers of the Polar Sea has also changed within the past few decades, the upper layer of cold water being much shallower now than in 1900. In the foreseeable future, if the trend continues, the thickness of the polar ice will continue to decrease until such time as the ice potential during a year equals the summer melting, when the regime will suddenly pass to a winter ice type, and immediate great changes in climate will take place. This change in thermal structure may presage the end of the current ice age.

The warming of the Arctic is presumed to be the cause of the rise in sea level which is noted over most seacoasts. The ice is gradually melting, not only from the glaciers and ice caps, but from the Arctic basin as well, and the volume of the oceans is gradually increasing. Complete melting of all ice of land and sea origin would raise the sea level at least 50 feet, thus causing great changes in land area along the Arctic coasts and reducing the source region of the coldest continental air. The long-range forecast for the Arctic basin is therefore to be ice-free and warmer.

E. FORECASTING AND THE POLAR PACK

The problems of ice forecasting of the polar pack may be divided into those connected with short- and long-range forecasts. Since short-range ice forecasting is primarily related to the meteorological situation, it will not be discussed here. The problem of long-range ice forecasting for periods of from 5 days to several months may be attacked through analysis of the upper-air structure and use of long-range meteorological forecasts, through analysis of the thermohaline structure and the water masses, and through calculation of the ice potential. This paper discusses only the implications of the theory of polar pack history upon the forecasting problem.

In forecasting the movements and extent of the polar pack, the forecast may be made in general and specific terms. By general is meant the characterization of the coming summer or winter as a light, normal, or heavy ice season. It is sufficient to predict the general extent of the shore lead, the concentration, and the relative proportions of winter and polar ice in the pack. For more specific forecasts it is necessary to forecast the thickness of the ice, the amount of surface melting, specific concentrations in the various portions of the pack, the breakup and freezeup conditions, the hardness, topography, rafting, pressure ridging and relief of the winter and polar ice, and similar factors.

The polar pack ice in summer is made up of from 10 to 20 percent winter ice and 75 to 85 percent polar ice. Melting proceeds more rapidly in the winter ice, as about 20 to 50 percent of the area of winter ice melts during the summer, while melting of the polar ice amounts to only about 1 to 2 percent of the area. The major loss of polar ice comes in the East Greenland drift, in which almost 10 percent of the polar ice leaves the polar basin annually. Thus, the average age of the polar ice is about 8 or 9 years, although some floes are much older than this and merit the name of paleocrystic ice. In fact, by postulating a uniform coverage from year to year the relative proportions of ice of all ages can be determined. For example, with a total surface coverage of 95 percent made up of 85 percent polar ice and 10 percent winter ice and with melting of the polar ice amounting to 1 percent of its total area, the mean age of the polar ice is 8.7 years. Of the polar ice, 10.5 percent is one year old, 19.8 percent is two years old or less, etc. More than half of the ice (53.6 percent) is seven years old or less, while 11.3 percent is more than 20 years old. The composition of the polar ice reveals that most of it is only a few years

old. Also, melting and gravity drift of salt particles downward combine to produce the typical appearance of polar ice after one summer's thawing. Once the winter ice fails to melt completely and becomes polar ice, it soon assumes the properties of polar ice and melts very slowly, eventually drifting into the East Greenland current. From the air the polar ice has a distinctive appearance and is readily distinguished from winter ice during the summer months. The melt puddles in winter ice form regular patterns, while the eroded pressure ridges and hummocks of old polar ice are irregular in pattern.

In forecasting the movement of the polar ice, its composition must be taken into account. The oceanographic factors influence winter ice much more than polar ice, so that the forecast will be different for different compositions of the pack. It will also be different in the region around the North Pole, where there is little winter ice, than it is in the Beaufort and Chukchi Seas where there is a large percentage of winter ice. The average age of the ice is greatest in the Lincoln Sea, where paleocrystic ice is the typical form.

From the above analysis of ice age and coverage, it appears possible to estimate the feasibility of taking a ship to the North Pole, the dream of many Arctic explorers. The approach from Greenland seems the most difficult and nearly impossible. The nearest approach to the pole was made by the icebreaker Sedov which was frozen into the ice and reached 86°39'N in August 1939, slightly north of the farthest point reached by the Fram in 1895. However, these ships were frozen into the ice and were not maneuverable. Consequently, they may be considered in the same class as rafts or ice floes like the Russian Station North Pole. In order to qualify as a maneuverable ship, the icebreaker should be able to change position during summer months and break out of the pack when necessary. On the basis of present experience, no ship has ever been built which is powerful enough to reach the North Pole under its own power. However, if the warming of the Arctic continues, it is possible that the more powerful ships of the future will be able to maneuver more and more within the Polar Basin. In the far distant future, all the ice may be melted and the Arctic Ocean may become another highway for seaborne commerce.

Table 1

MELTING PERCENTAGES OF WINTER ICE AND AGE OF POLAR ICE
FOR SUMMER SURFACE COVERAGE OF 95 PERCENT

Assuming a loss of 10 percent by current outflow, the melting percentages of the winter ice and the average age of the polar ice are given for different percentages of areal melting of polar ice.

SURFACE Winter Ice	COVERAGE Polar Ice	MELTING PERCENTAGES OF POLAR ICE 1	2	5
6%	89%	40.0% 9.1 Years		
7	88	36.4 9.0	30.0 8.3	
8	87	33.3 8.9	27.3 8.25	
9	86	30.8 8.8	25.0 8.2	
10	85	28.6 8.7	23.1 8.1	0.0 6.7
15	80	21.1 8.3	16.7 7.7	0.0 6.3
20	75	16.7 7.8	13.0 7.2	0.0 6.0
25	70	13.8 7.4	10.4 6.8	0.0 5.7

Table 2

MELTING PERCENTAGES OF WINTER ICE AND AGE OF POLAR ICE
FOR SUMMER SURFACE COVERAGE OF 90 PERCENT

Assuming a loss of 10 percent by current outflow, the melting percentages of the winter ice and the average age of the polar ice are given for different percentages of areal melting of polar ice.

SURFACE COVERAGE Winter Ice	SURFACE COVERAGE Polar Ice	MELTING PERCENTAGES OF POLAR ICE 1	2	5	10
1%	89%	90.0% 9.1 Years			
2	88	81.8 9.0	80.0 8.3		
3	87	75.0 8.9	72.7 8.25		
4	86	69.2 8.8	66.7 8.2		
5	85	64.3 8.7	61.5 8.1	50.0 6.7	
6	84	60.0 8.6	56.7 8.0	45.5 6.6	
7	83	56.2 8.5	53.3 7.9	41.7 6.5	
8	82	52.9 8.5	50.0 7.8	38.5 6.5	
9	81	50.0 8.4	47.1 7.75	35.7 6.4	
10	80	47.4 8.3	44.4 7.7	33.3 6.3	0.0 5.0
15	75	37.5 7.8	34.8 7.2	25.0 6.0	0.0 4.8
20	70	31.0 7.4	28.6 6.8	20.0 5.7	0.0 4.5
25	65	26.5 6.9	24.2 6.4	16.7 5.3	0.0 4.2
30	60	23.1 6.5	21.1 6.0	14.3 5.0	0.0 4.0

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